USB-1616FS

Analog Input and Digital I/O

User's Guide

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Table of Contents

About this User's Guide

What you will learn from this user's guide

This user's guide describes the Measurement Computing USB-1616FS data acquisition device and lists device specifications.

Conventions in this user's guide

For more information
Text presented in a box signifies additional information and helpful hints related to the subject matter you are reading.

Caution! Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

bold text — **Bold** text is used for the names of objects on a screen, such as buttons, text boxes, and check boxes.

italic text — *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase.

Where to find more information

Additional information about the USB-1616FS is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation by phone, fax, or email with specific questions.

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@mccdaq.com

Introducing the USB-1616FS

The USB-1616FS is a USB 2.0 full-speed device supported under popular Microsoft® Windows® operating systems.

The USB-1616FS provides true simultaneous sampling of up to sixteen 16-bit single-ended analog inputs. Simultaneous input sampling is accomplished through the use of one A/D converter per channel. The module features sampling rates of up to 50 kS/s per channel, and up to 9500 S/s per channel throughput for all channels. You can configure the analog input range of each channel independently via software. An onboard temperature sensor lets you monitor your environment temperature.

Eight digital IO lines are independently selectable as input or output. A 32-bit counter can count TTL pulses. A SYNC (synchronization) control line lets you synchronize two USB-1616FS modules to acquire data synchronously from 32 analog inputs.

The USB-1616FS is powered by an external +9 V unregulated power supply that is shipped with the board. Power and USB connectors let you power and control multiple MCC USB Series products from one external power source and one USB port in a daisy chain fashion.

The USB-1616FS is enclosed in a rugged housing that you can mount on a DIN rail or on a bench (see Figure 1).

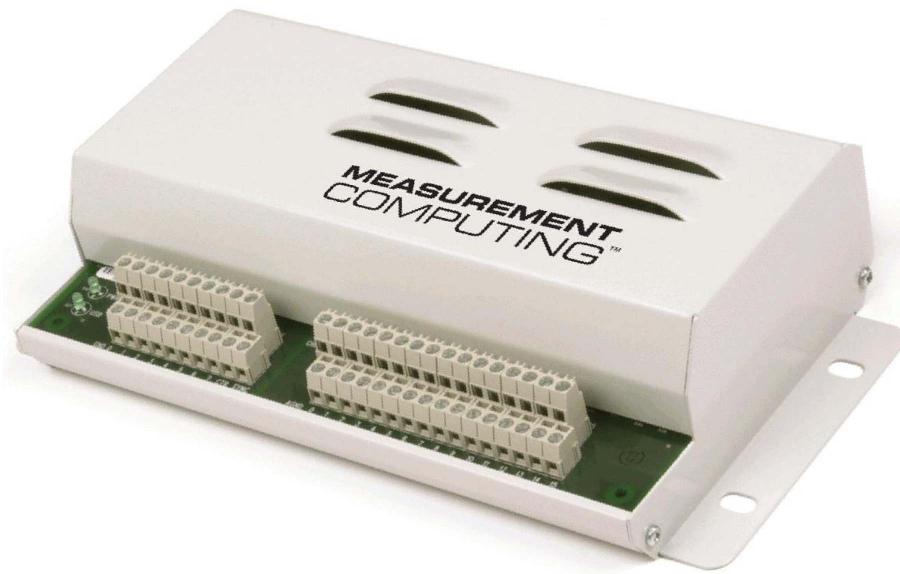

Figure 1. USB-1616FS

Functional block diagram

USB-1616FS functions are illustrated in the block diagram shown here.

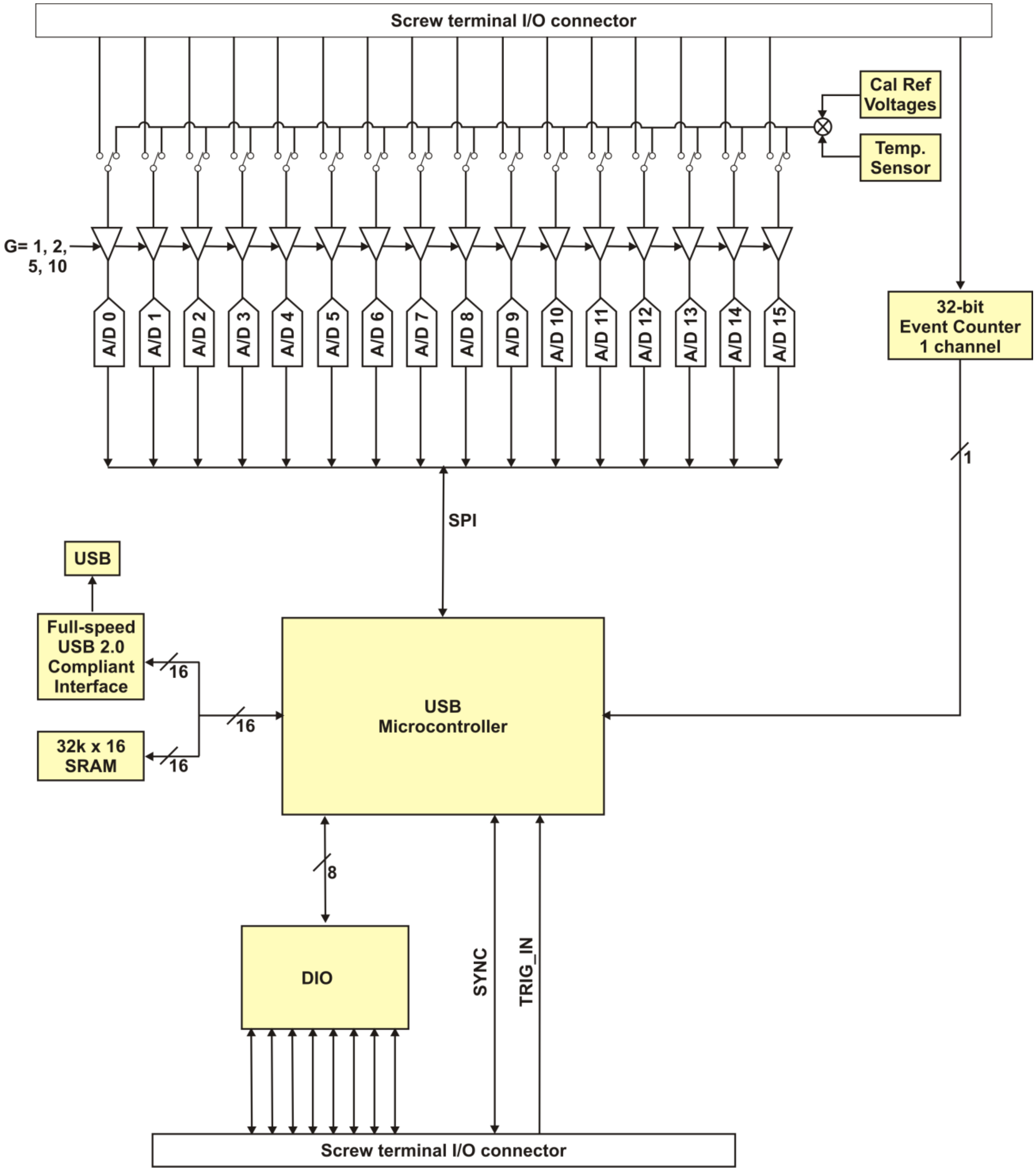

Figure 2. USB-1616FS functional block diagram

Connecting a USB-1616FS to your computer is easy

Installing a data acquisition device has never been easier.

- The USB-1616FS relies upon the Microsoft Human Interface Device (HID) class drivers. The HID class drivers ship with every copy of Windows that is designed to work with USB ports. We use the Microsoft HID because it is a standard, and its performance delivers full control and maximizes data transfer rates for your USB-1616FS. No third-party device driver is required.
- The USB-1616FS is plug-and-play. There are no jumpers to position, DIP switches to set, or interrupts to configure.
- You can connect the USB-1616FS before or after you install the software, and without powering down your computer first. When you connect an HID to your system, your computer automatically detects it and configures the necessary software. You can connect and power multiple HID peripherals to your system using a USB hub.

  You can connect up to four USB-1616FS devices to one USB 2.0 port. You can connect up to two devices to a USB 1.1 port.
- You can connect your system to various devices using a standard four-wire cable. The USB connector improves upon serial and parallel port connectors with one standardized plug and port combination.
- Data can flow two ways between a computer and peripheral over USB connections.

Installing the USB-1616FS

What comes with your USB-1616FS shipment?

The following items are shipped with the USB-1616FS.

Hardware

- USB-1616FS
- USB cable (24 AWG VBUS/GND, 2 meter length)
- External power supply and cord (CB-PWR-9V3A) – 9 volt, 3 amp DC power supply

Software

- MCC DAQ CD

Documentation

In addition to this hardware user's guide, you should also receive the *Quick Start Guide*. This booklet provides an overview of the MCC DAQ software you received with the device, and includes information about installing the software. Please read this booklet completely before installing any software or hardware.

Unpacking

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the USB-1616FS from its packaging, ground yourself using a wrist strap or by simply touching the computer chassis or other grounded object to eliminate any stored static charge.

If your USB-1616FS arrives already damaged, notify Measurement Computing Corporation immediately by phone, fax, or email. For international customers, contact your local distributor where you purchased the USB-1616FS.

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@mccdaq.com
-

Installing the software

Refer to the *Quick Start Guide* for instructions on installing the software on the MCC DAQ CD. This booklet is available in PDF at www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf.

Installing the hardware

Before you connect the USB-1616FS to your computer, connect the external power supply that was shipped with the device.

You can connect up to four MCC USB Series devices in a daisy chain configuration to a single USB 2.0 port on your computer. If your system has a USB 1.1 port, you can connect up to two MCC USB Series devices.

Connecting the external power supply

Power to the USB-1616FS is provided with the +9 V external power supply (CB-PWR-9V3A). You must connect the external power supply *before* connecting the USB cable to the USB-1616FS and your computer.

Complete the following steps to connect the power supply to the USB-1616FS:

1. Connect the external power cord to the **POWER IN** connector on the rear of the USB-1616FS enclosure. This connector is labeled **IN** on the board.
2. Plug the power supply into a power outlet.

The **PWR** LED is on (green) when +9 V power is supplied to the USB-1616FS. If the voltage supply is less than +6.0 V or more than +12.5 V, the **PWR** LED is off.

Do not connect external power to the POWER OUT connector

The power connector labeled **POWER OUT** on the enclosure (**OUT** on the board) provides power to an additional MCC USB Series product. If you connect the external power supply to the **POWER OUT** connector, the USB-1616FS does not receive power, and the **PWR** LED does not turn on.

Connecting the USB-1616FS to your system

To connect the USB-1616FS to your system, do the following.

1. Connect the USB cable that was shipped with the device to the USB connector labeled **USB IN** on the USB-1616FS.

   The USB cable supplied with the USB-1616FS has a higher gauge wire than generic USB cables, and is required for proper enumeration of the USB-1616FS.
2. Connect the other end of the USB cable to a USB port on your computer or to an external USB hub that is connected to your computer. The **PWR LED** turns on (green). The USB cable provides power and communication to the USB-1616FS.

The USB-1616FS installs as a composite device with separate devices attached. When you connect the device for the first time, a **Found New Hardware** dialog opens as each device interface is detected. This is normal. After the device is installed its LED will blink and then remain on. This indicates that communication is established between the USB-1616FS and your computer.

If you are running Windows XP and connect the device to a USB 1.1 port, a balloon displays the message "**Your USB device can perform faster if you connect to a USB 2.0 port**." You can ignore this message. The USB-1616FS functions properly when connected to a USB 1.1 port, although USB bandwidth is limited.

If the USB LED turns off

If communication is lost between the device and the computer, the USB LED turns off. Disconnect the USB cable from the computer and then reconnect it. This should restore communication, and the USB LED should turn on.

If your system does not detect the USB-1616FS

If a "**USB device not recognized**" message appears when you connect the USB-1616FS, do the following.

1. Unplug the USB cable from the USB-1616FS.
2. Unplug the external power cord from the **POWER IN** connector on the enclosure.
3. Plug the external power cord back into the **POWER IN** connector.
4. Plug the USB cable back into the USB-1616FS.

Your system should now properly detect the USB-1616FS hardware. Contact technical support if your system still does not detect the USB-1616FS.

Removing USB-1616FS boards from Windows XP systems

Device Manager may require up to 30 seconds to detect the removal of a USB-1616FS board from a Windows XP system with Service Pack 1 or Service Pack 2 installed. This time increases with each additional connected board. If you remove four boards from your system, the time required for Device Manager to update may be almost two minutes.

If you re-attach the USB-1616FS to your system before Device Manager updates, the USB LED will not turn on. Your system will not detect new hardware until Device Manager first detects that hardware has been removed. The InstaCal software will be unresponsive during this re-detection time. Wait until Device Manager updates with the new hardware before running InstaCal. The USB-1616FS is detected by the system when the device LED is on.

Functional Details

Analog input acquisition modes

The USB-1616FS can acquire analog input data in three basic modes – software paced, continuous scan, and burst scan.

Software paced

With software paced mode you acquire one analog sample at a time. You initiate the A/D conversion by calling a software command. The analog value is converted to digital data and returned to the computer. Repeat this procedure until you have the total number of samples that you want from one channel.

The maximum throughput sample rate in software paced mode is about 250 S/s, but may vary depending on your system. You may receive OVERRUN errors at higher rates on some platforms. Using the burst scan mode (BURSTIO) should resolve these problems.

Continuous scan

With hardware paced mode you acquire data from up to 16 channels simultaneously. The analog data is continuously acquired, converted to digital values, and written to an on-board FIFO buffer on the USB-1616FS until you stop the scan. The FIFO buffer is serviced in blocks as the data is transferred from the device FIFO buffer to the memory buffer on your computer.

You can acquire data with the USB-1616FS from one channel at 50 kS/s and up to 16 channels at 9.5 kS/s each. The throughput rates for 1 to 16 channels are listed in the *Specifications* section on page 23. You can start a continuous scan with either a software command or with an external hardware trigger event.

Burst scan

With burst scan mode (BURSTIO), you can acquire data using the full capacity of its 32 k sample FIFO on the device. The acquired data is then read from the FIFO and transferred to a user memory buffer on the computer. You can initiate a single acquisition sequence for any number of input channels by either a software command or an external hardware trigger.

Burst scans are limited to the depth of the on-board memory, as the data is acquired at a rate faster than it can be transferred to the computer. The maximum sampling rate is an aggregate rate, where the total acquisition rate for all channels is 200 kS/s divided by the number of channels. The maximum rate for each channel is 50 kS/s. The maximum rate that you can acquire data using burst scan mode is 50 kS/s per channel for one, two, or four channels, and 12.5 kS/s per channel for 16 channels.

Internal components

Major components on the USB-1616FS are shown in Figure 3.

- Two (2) USB connectors
- Two (2) external power connectors
- USB LED
- PWR LED
- Four (4) Screw terminal banks

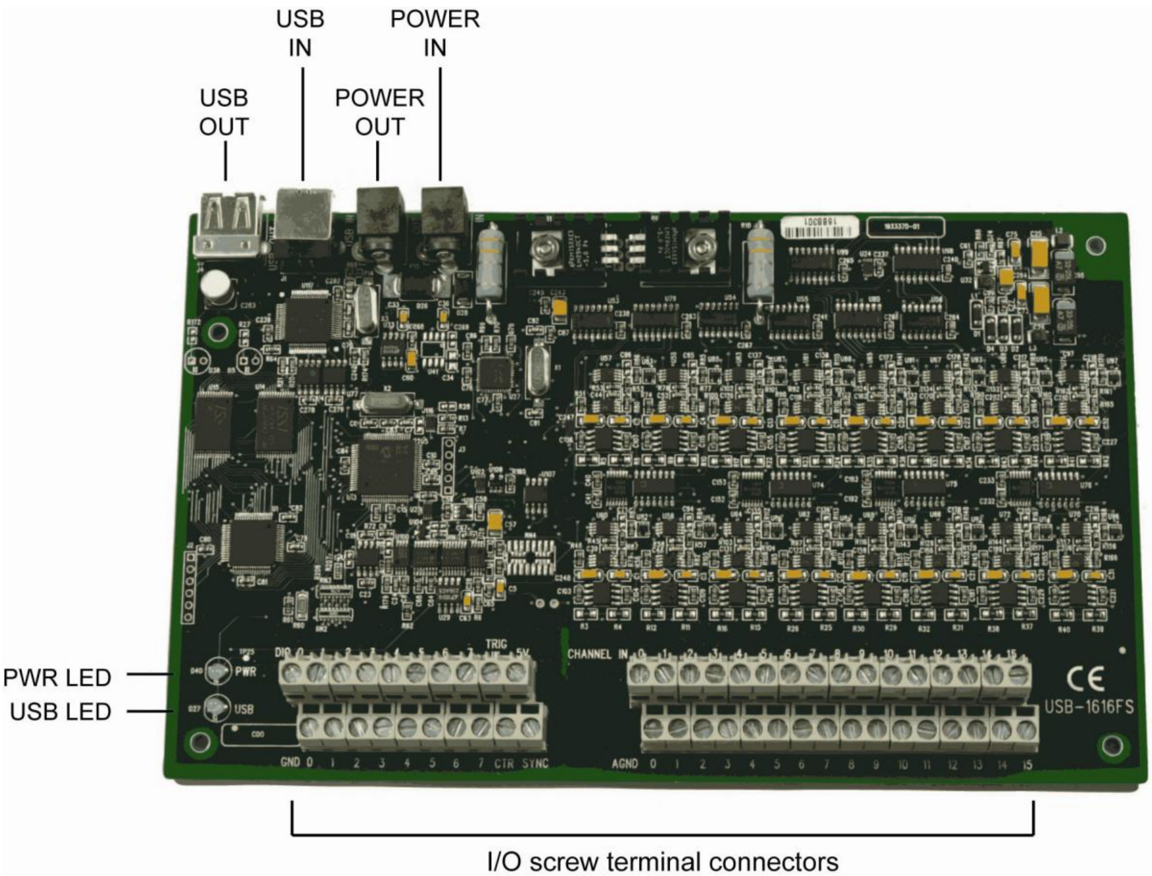

Figure 3. USB-1616FS internal components

USB OUT connector

The **USB OUT** connector is a downstream hub output port intended for use with other MCC USB Series products only. The USB hub is self-powered, and can provide 100 mA maximum current at 5 V. The USB out connector is labeled USB OUT on the enclosure and on the board.

For information on daisy chaining to other MCC USB Series products, refer to Daisy chaining additional devices to the USB-1616FS on page 17.

USB IN connector

Connect the **USB IN** connector to the USB port on your computer (or USB hub connected to your computer). The USB in connector is labeled **USB IN** on the enclosure and on the board.

External power connectors

The USB-1616FS has two external power connectors labeled **POWER IN** and **POWER OUT** on the enclosure. The **POWER IN** connector is labeled **IN** on the board, and the **POWER OUT** connector is labeled **OUT** on the board.

To supply external power, connect the **POWER IN** connector to the supplied +9 V external power supply (CB-PWR-9V3A).

The **POWER OUT** connector lets you power additional daisy chained MCC USB Series devices from a single external power supply. The C-MAPWR-x cable is available from MCC to connect additional MCC USB Series devices.

USB LED

The **USB** LED indicates the communication status of the USB-1616FS. This LED uses up to 5 mA of current and cannot be disabled. The table below explains the behavior of the USB LED.

USB LED Illumination

USB LED	**Indication**
Steady green	The USB-1616FS is connected to a computer or external USB hub.
Blinks continuously	Initial communication is established between the USB-1616FS and the computer, or data is being transferred.

PWR LED

The USB-1616FS incorporates an on-board voltage supervisory circuit that monitors the USB VBUS (5V) and the external 9 V power supply. If the input voltage falls outside of the specified ranges the **PWR** LED shuts off (see table below).

PWR LED Illumination

PWR LED illumination	**Indication**
Steady green	USB +5 V power or +9 V external power is supplied to the device.
Off	Input power is not supplied, or a power fault has occurred. A power fault occurs when the input power falls outside of the specified voltage range: ▪ USB VBUS (+5 V): 4.75 V to 5.25 V ▪ External power: (+9 V): 6.0 V to 12.5 V

Screw terminals

The device has two rows of screw terminals. Each row has 26 connections. Signal labels are shown in Figure 4.

Figure 4. USB-1616FS screw terminals

The screw terminals provide the following connections:

- eight digital I/O terminals (**DIO 0** to **DIO 7**)
- one external digital trigger terminal (**TRIG IN**)
- one power terminal (**5V**)
- eight ground terminals (**GND 0** to **7**)
- one external event counter terminal (**CTR**)
- one terminal for external clocking and multi-unit synchronization (**SYNC**)
- 16 analog input terminals (**CHANNEL IN 0 to 15**)
- 16 analog ground terminals (**AGND 0 to 15**)

Use 14 AWG to 30 AWG wire for your signal connections.

Caution! Keep the length of stripped wire at a minimum to avoid a short to the enclosure! When connecting your field wiring to the screw terminals, use the strip gage on the terminal strip, or strip to 5.5 - 7.0 mm (0.215" to 0.275") long.

Each screw terminal is identified with a label on the board and on the underside of the enclosure lid. Refer to the table below for the signal name associated with each board label.

Board labels and associated signal names

Board label		Signal name	Board label		Signal name
DIO	0	DIO 0	GND	0	GND 0
	1	DIO 1		1	GND 1
	2	DIO 2		2	GND 2
	3	DIO 3		3	GND 3
	4	DIO 4		4	GND 4
	5	DIO 5		5	GND 5
	6	DIO 6		6	GND 6
	7	DIO 7		7	GND 7
TRIG IN		TRIG IN	CTR		CTR
5V		5V	SYNC		SYNC
CHANNEL IN	0	CH 0	AGND	0	AGND 0
	1	CH 1		1	AGND 1
	2	CH 2		2	AGND 2
	3	CH 3		3	AGND 3
	4	CH 3		4	AGND 4
	5	CH 4		5	AGND 5
	6	CH 5		6	AGND 6
	7	CH 6		7	AGND 7
	8	CH 8		8	AGND 8
	9	CH 9		9	AGND 9
	10	CH 10		10	AGND 10
	11	CH 11		11	AGND 11
	12	CH 12		12	AGND 12
	13	CH 13		13	AGND 13
	14	CH 14		14	AGND 14
	15	CH 15		15	AGND 15

Signal connections

Analog inputs

You can connect up to 16 analog input connections (**CH0 IN** through **CH15 IN**) to the screw terminals labeled **Channel IN 0-15**. We recommend that you connect unused analog input terminals to ground terminals during operation. For example, if you are not using **CH7 IN**, connect this terminal to **AGND 7**.

The analog input channels are configured for single-ended input mode. Each analog signal is referenced to signal ground (AGND), and requires two wires:

- Connect the wire carrying the signal to be measured to **CH# IN**.
- Connect the second wire to **AGND**.

The input voltage ranges are ±10 V, ±5 V, ±2.0 V, and ±1.0 V.

For more information on analog signal connections

For more information on single-ended inputs, refer to the *Guide to Signal Connections* (this document is available on our web site at www.mccdaq.com/signals/signals.pdf).

Channel-gain queue

The channel-gain queue feature allows you to configure a different gain setting for each channel. The gain settings are stored in a channel-gain queue list that is written to local memory on the device.

The channel-gain queue list can contain up to 16 unique elements. The channel list must be in increasing order. An example of an 8-element list is shown in the following table.

Sample channel-gain queue list

Element	Channel	Range
0	CH0	BIP10V
1	CH1	BIP5V
2	CH2	BIP10V
3	CH3	BIP1V
4	CH4	BIP2V
5	CH5	BIP10V
6	CH6	BIP1V
7	CH7	BIP5V

Carefully match the gain to the expected voltage range on the associated channel or an over range condition may occur. Although this condition does not damage the device, it does produce a useless full-scale reading, and can introduce a long recovery time due to saturation of the input channel.

Digital I/O

You can connect up to eight digital I/O lines to the screw terminals labeled **DIO 0** to **DIO 7**. Each digital channel is individually configurable for input or output.

The digital I/O terminals can detect the state of any TTL-level input. Refer to the schematic shown in Figure 5.

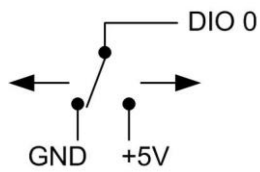

Figure 5. Schematic showing switch detection by digital channel DIO0

If you set the switch to the +5 V input, DIO 0 reads *TRUE* (1). When set to GND, DIO 0 reads *FALSE* (0).

Pull-up/down configuration

All digital I/O lines are pulled up by default to USB +5V with a 47 kΩ resistor. To configure for pull-down, the board must be modified at the factory.

For more information on digital signal connections

For general information regarding digital signal connections and digital I/O techniques, refer to the *Guide to Signal Connections* (available on our web site at www.mccdaq.com/signals/signals.pdf).

Counter input

The CTR terminal (**CTR**) is a TTL level input to a 32-bit event counter. The internal counter increments when the TTL level transitions from low to high. The counter can count frequencies of up to 1 MHz.

Trigger input

The trigger terminal (**TRIG IN**) is an external digital trigger input. You can configure this terminal with software for either rising (default) or falling edge.

SYNC I/O

The **SYNC** terminal is a bidirectional I/O signal that can be configured as an input or an output:

- Configure as an external clock input to externally clock the A/D conversions. The **SYNC** terminal supports TTL-level input signals.
- Configure as an output to synchronize with a second USB-1616FS and acquire data from 32 channels. For more information about synchronized operations see page 20.

Power output

The **+5V** terminal (labeled **5V**) draws power from either the USB connector VBUS terminal or the external power supply.

Caution! The +5V terminal is an output. Do not connect to an external power supply or you may damage the USB-1616FS and possibly the computer.

The maximum amount of +5 V current from the +5 V terminal is limited to 50 mA.

Ground terminals

The analog ground (**AGND**) terminals provide a common ground for all analog channels.

The digital ground (**GND**) terminals provide a common ground for the digital, trigger, counter, sync and power terminals.

Daisy chaining additional devices to the USB-1616FS

Daisy chained MCC USB Series products connect to the USB bus through the high-speed hub on the USB-1616FS. You can daisy chain a maximum of four MCC USB Series products to a single USB 2.0 port on your computer, or a maximum of two devices to a single USB 1.1 port. Use the supplied cable or an equivalent cable for daisy chaining to additional MCC USB Series products.

MCC USB Series products are USB 2.0 full-speed devices that provide a signaling bit rate of 12 Mb/s. The throughput rate is shared by all devices connected to the USB bus.

Complete the following steps to daisy-chain two or more USB-1616FS devices. This procedure assumes you already have one USB-1616FS connected to a computer and to the external power source. The USB-1616FS already connected to the computer is referred to as the *connected device*. The USB-1616FS you want to daisy-chain to the connected device is referred to as the *new device*.

1. Connect the **Power OUT** connector on the connected device to the **POWER IN** connector on the new device.
2. Connect the **USB OUT** connector on the connected device to the **USB IN** connector on the new device.
3. For each additional device you want to add, repeat steps 1-2, with the device you just daisy chained now being the *connected device*.

Sample rate limitations when using multiple USB-1616FS devices

The maximum sample rate when using multiple USB-1616FS boards is system-dependent. Multiple board performance is limited by an overall aggregate sample rate. The maximum throughput is in number of samples taken per second. The rate is irrespective of the number of channels sampled or the number of boards installed. The maximum sample rate of any one channel is limited to 50 KS/s.

The typical limiting factor for throughput is CPU usage. At maximum system throughput, virtually all available CPU power is consumed by the USB data transfer. When you run your system close to its maximum throughput, the amount of CPU power that is available for running other concurrent processes is limited. Benchmark performance rates are listed in the *Specifications* chapter on page 23.

Power limitations when using multiple USB-1616FS devices

When daisy chaining additional MCC USB Series products to the USB-1616FS, you must ensure that you provide adequate power to each board that you connect. The USB-1616FS is powered with a 9 VDC nominal, 3.0 A external power supply.

Voltage drop

A drop in voltage occurs with each board connected in a daisy chain system. The voltage drop between the power supply input and the daisy chain output is 0.5 V maximum. Factor in this voltage drop when you configure a daisy chain system to ensure that at least 6.0 VDC is provided to the last board in the chain.

Accuracy

The overall accuracy of any instrument is limited by the error components within the system. Quite often, resolution is incorrectly used to quantify the performance of a measurement product. While "16-bits" or "1 part in 65,536" does indicate what can be resolved, it provides little insight into the quality, or accuracy, of an absolute measurement. Accuracy specifications describe the actual measurement that can be relied upon with a USB-1616FS.

There are three types of errors which affect the accuracy of a measurement system:

- offset
- gain
- nonlinearity

The primary error sources in the USB-1616FS are offset and gain. Nonlinearity is small in the USB-1616FS, and is not significant as an error source with respect to offset and gain.

Figure 6 shows an ideal, error-free, USB-1616FS transfer function. The typical calibrated accuracy of the USB-1616FS is range-dependent, as explained in the "Usage note" in the Specifications chapter. We use a ±10V range as an example of what you can expect when performing a measurement in this range.

The accuracy plot in Figure 6 is drawn for clarity and is not drawn to scale.

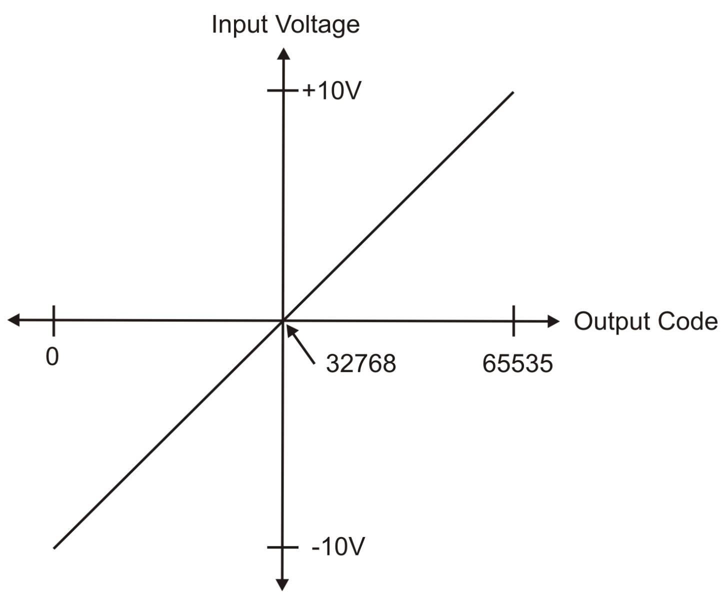

Figure 6. Ideal USB-1616FS transfer function

The USB-1616FS offset error is measured at mid-scale. Ideally, a zero volt input should produce an output code of 32,768. Any deviation from this is an offset error. Figure 7 shows the USB-1616FS transfer function with an offset error. The typical offset error specification for the USB-1616FS on the ±10 V range is ±1.66 mV. Offset error affects all codes equally by shifting the entire transfer function up or down along the input voltage axis.

The accuracy plots in Figure 7 are drawn for clarity and are not drawn to scale.

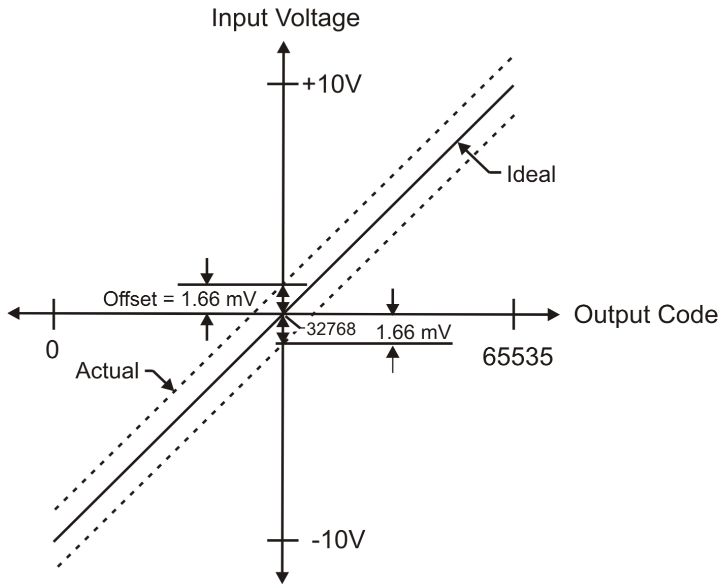

Figure 7. USB-1616FS transfer function with offset error

Gain error is a change in the slope of the transfer function from the ideal, and is typically expressed as a percentage of full-scale. Figure 8 shows the USB-1616FS transfer function with gain error. Gain error is easily converted to voltage by multiplying the full-scale input (±10 V) by the error.

The accuracy plots in Figure 8 are drawn for clarity and are not drawn to scale.

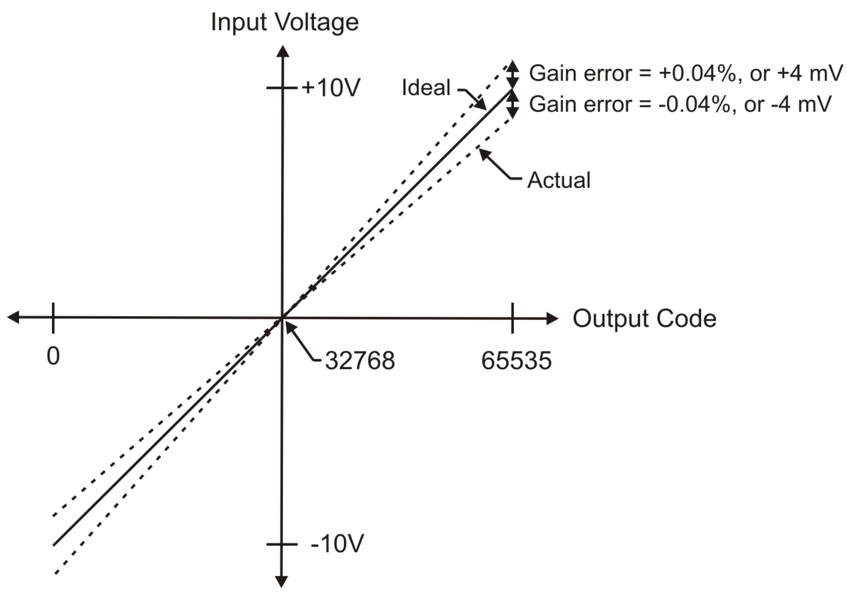

Figure 8. USB-1616FS transfer function with gain error

For example, the USB-1616FS exhibits a typical calibrated gain error of ±0.04% on all ranges. For the ±10 V range, this would yield 10 V × ±0.0004 = ±4 mV. This means that at full scale, neglecting the effect of offset for the moment, the measurement would be within 4 mV of the actual value. Note that gain error is expressed as a ratio. Values near ±FS (±10 V) are more affected from an absolute voltage standpoint than are values near mid-scale, which see little or no voltage error.

Combining these two error sources in Figure 9, we have a plot of the error band of the USB-1616FS at ±full scale (±10 V). This plot is a graphical version of the typical accuracy specification of the product.

The accuracy plots in Figure 9 are drawn for clarity and are not drawn to scale.

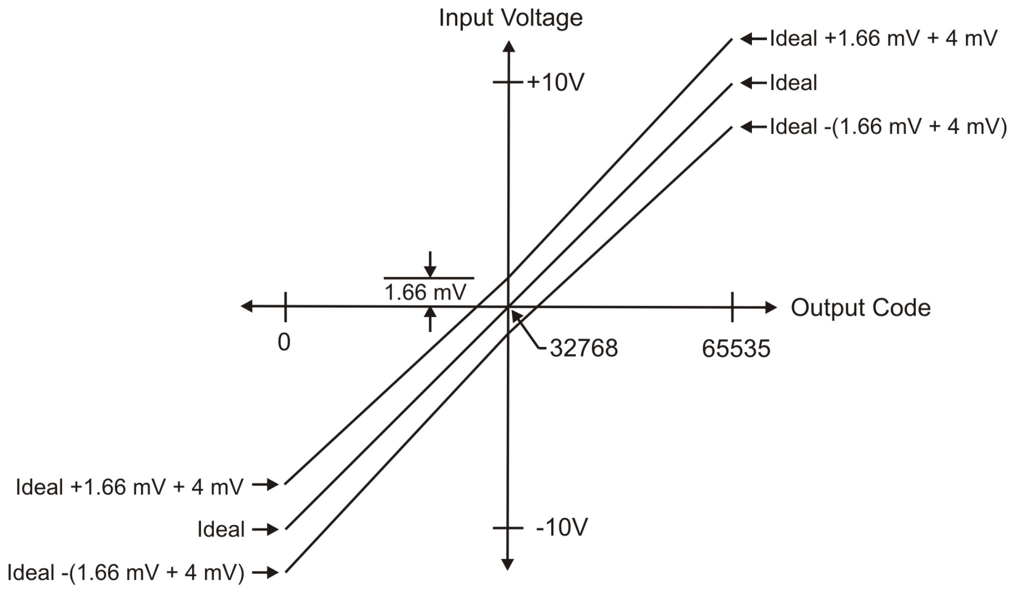

Figure 9. USB-1616FS error band plot

Synchronized operations

You can connect up to four USB-1616FS devices to one USB 2.0 port. You can connect up to two devices to a USB 1.1 port.

You can connect the SYNC pin of two USB-1616FS units together in a master/slave configuration and acquire data synchronously from 32 channels. When the SYNC pin is configured as an output, the internal A/D pacer clock signal is present at the screw terminal. You can output the A/D pacer clock to the SYNC pin of a second USB-1616FS configured for A/D pacer input.

Change to SYNC pin setting not implemented until first scan

When you change the setting of the SYNC pin to input or to output using InstaCal, the change does not take place until you run a scan with the USB-1616FS.

Consequently, if you change the SYNC pin from output to input, the SYNC pin remains an output, and connections to this pin are connections to an output, until the first scan runs. This will not damage the USB-1616FS.

To update the SYNC pin setting before connecting the SYNC pin, run the InstaCal analog **Scan Test**.

Mechanical drawings

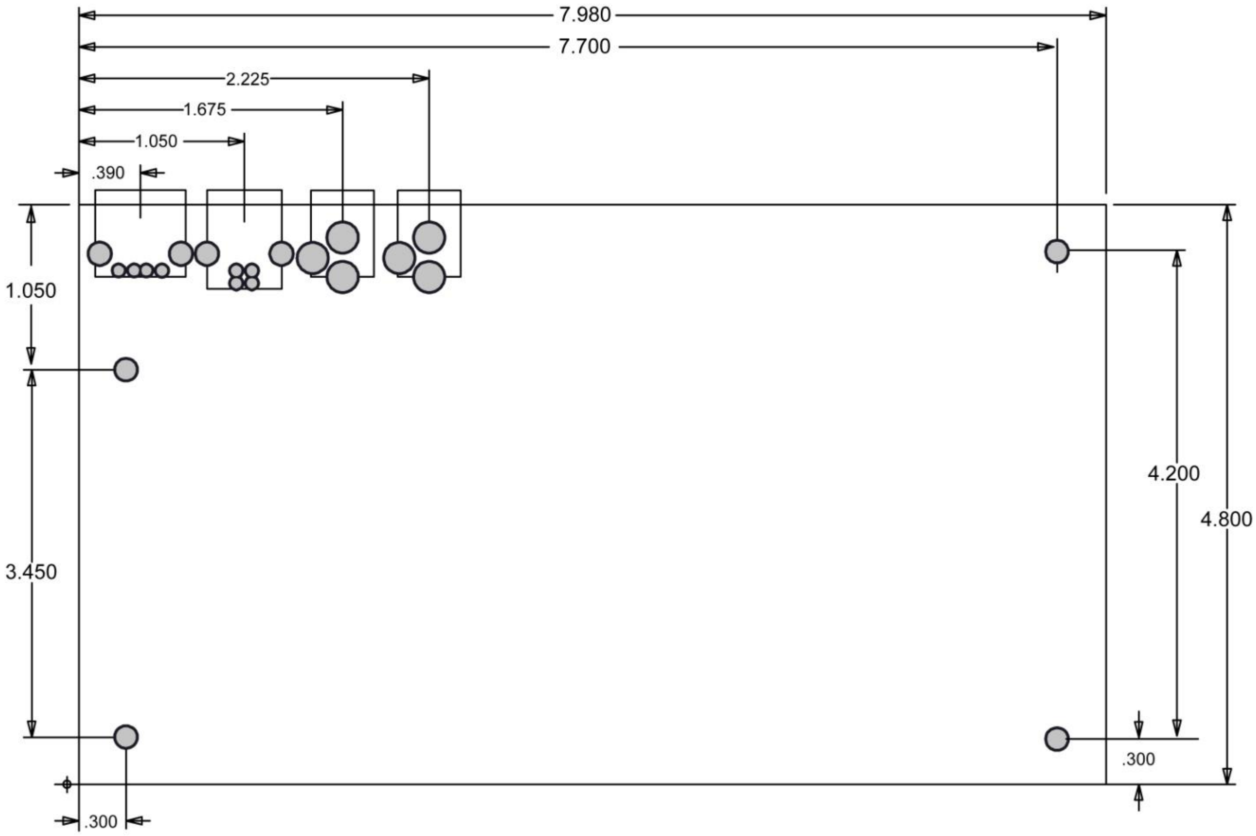

Figure 10. USB-1616FS circuit board dimensions

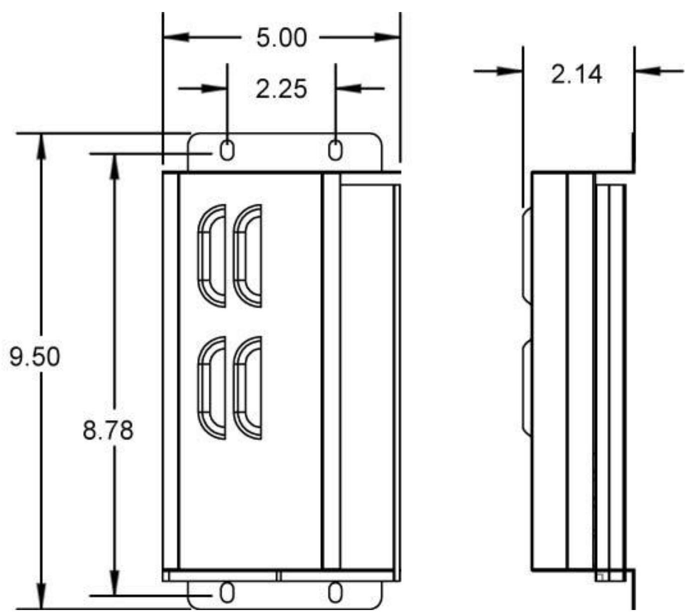

Figure 11. USB-1616FS enclosure dimensions

Specifications

All specifications are subject to change without notice.
Typical for 25 °C unless otherwise specified.
Specifications in *italic text* are guaranteed by design.

Analog input

Table 1. AI specifications

Parameter	Conditions	Specification
A/D converters		16-bit, SAR type
Number of channels		16 single-ended
Input configuration		Individual A/D per channel
Sampling method		Simultaneous
Absolute maximum input voltage	*CHx IN to GND*	*±15 V max*
Input impedance		100 MΩ, min
Input bandwidth (–3 dB)		50 kHz typ
Input leakage current		±1 µA typ
Input capacitance		*50 pf typ*
Offset temperature drift		15 ppm/°C typ
Gain temperature drift	All ranges	35 ppm/°C typ
Input ranges	Software selectable	±10 V, ±5 V, ±2 V, ±1 V
Sampling rate	Scan to PC memory	0.6 S/s to 50 kS/s, software programmable
	Burst scan to 32 k sample FIFO	20 S/s to 50 kS/s, software programmable
Throughput	Software paced	30 S/s to 500 S/s all channels; throughput is system dependant)
	Scan to PC memory	Refer to the Single Board Throughput and Multiple Board Throughput sections that follow this table.
	Burst scan to 32 k sample FIFO	= (200 kS/s) / (# of channels), max of 50 kS/s for any channel
Gain queue		Software configurable. Sixteen elements, one gain element per channel.
Resolution		16 bits
No missing codes		*15 bits*
Crosstalk	DC – 25 kHz (sine)	–80 dB min
Calibration voltages		0 V, ±0.625 V, ±1.25 V, ±2.5 V, ±5.0 V, software selectable
Calibration voltage accuracy (Note 1)		±0.5% typ, ±1.0% max
Temperature sensor range		0 °C to +70 °C max
Temperature sensor accuracy		±3 °C typ
Trigger source	Software selectable	External digital: TRIG_IN

Note 1: Actual values used for calibration are measured and stored in EEPROM.

Single board throughput

The USB-1616FS has an integral USB hub, which allows up to four USB-1616FS devices to be daisy chained and connected to a single USB 2.0 port on the host computer. The data shown in Table 2 reflects the throughput that can be expected in single board systems. For details on throughput in systems using multiple USB-1616FS devices, refer to Multiple board throughput below.

Table 2. Single board throughput: Scan to PC memory specifications

Number of Input Channels	**Per-channel Throughput (kS/s) (Note 2)**
1	50000
2	50000
3	36000
4	30000
5	25000
6	22000
7	19000
8	17000
9	15000
10	14000
11	12500
12	12000
13	11250
14	10500
15	10000
16	9500

Note 2: The throughput data in Table 2 applies to a single USB-1616FS installation only. Maximum throughput scanning to PC memory is machine dependent. The rates specified in Table 2 is for Windows XP only.

Multiple board throughput

The USB-1616FS has an integral USB hub, which allows up to four USB-1616FS devices to be daisy chained and connected to a single USB 2.0 port on the host computer. The data shown in Table 2 reflects the throughput that can be expected in single board systems.

The transfer of USB-1616FS data over the USB bus is CPU intensive. The transfer rate using multiple USB-1616FS devices is both CPU intensive and system dependent. This makes it impossible for us to provide a guaranteed multi-board maximum sample rate specification. However, the benchmark performance shown below should serve as a guide for what you may expect.

Multiple board performance is limited by an overall aggregate sample rate. The maximum throughput will be in number of samples taken per second irrespective of the number of channels sampled* or number of devices installed. For example, if the maximum throughput in a system is 150,000 samples per second, you may sample 20 channels at 7.5 kS/s, 30 channels at 5 kS/s, 40 channels at 3.75 kS/s, and so on.

* The maximum sample rate of any one channel is limited to 50 kS/s.

Throughput benchmarks

Table 3. Throughput specifications

Throughput (kS/s)	System
240	2.4 GHz P4 running Win XP, Service Pack 2, using an integrated USB Enhanced Host Controller (EHC) port
240	2.4 GHz P4, Phoenix BIOS, Win XP, Service Pack 2, integrated USB EHC port
130	2 GHz, Xeon, Win XP, Service Pack 2, hyperthreading turned OFF, using an integrated USB EHC port
220	2 GHz, Xeon, Win XP, Service Pack 2, hyperthreading turned ON, using an integrated USB EHC port
260	2.4 GHz, P4 running Win XP, Service Pack 1, using Belkin PCI-bus USB 2.0 card
250	2.4 GHz, P4 running Win XP, Service Pack 1, using StarTec PCI-bus USB 2.0 card

Usage note

The typical limiting factor on throughput is CPU usage. At maximum system throughput, virtually all available CPU power will be consumed by the USB data transfer. This is an important note since running your system close to its maximum throughput will certainly limit the amount of CPU power available for running other concurrent processes (for example, plotting or real-time analysis).

Table 4. Calibrated absolute accuracy specifications

Range	Accuracy (mV)
±10 V	±5.66
±5 V	±2.98
±2 V	±1.31
±1 V	±0.68

Table 5. Accuracy components specifications – all values are (±)

Range	% of Reading	Gain Error at FS (mV)	Offset (mV)
±10 V	0.04	4.00	1.66
±5 V	0.04	2.00	0.98
±2 V	0.04	0.80	0.51
±1 V	0.04	0.40	0.28

Table 6. Noise performance specifications

Range	Typical Counts	LSBrms
±10 V	10	1.52
±5 V	10	1.52
±2 V	11	1.67
±1 V	14	2.12

Noise distribution is determined by gathering 50 k samples with analog inputs tied to ground (AGND) at the user connector. Samples are gathered at the maximum specified sampling rate of 50 kS/s.

Digital input/output

Table 7. Digital I/O specifications

Digital type	CMOS
Number of I/O	8 (DIO0 through DIO7)
Configuration	Independently configured for input or output
Pull up/pull-down configuration	All pins pulled up to USB VBUS via 47 kΩ resistors (default). Positions are available for pull-down to ground (GND). Hardware selectable via 0 Ω resistors is available as a factory option.
Digital I/O transfer rate (software paced)	System dependent, 33 port reads to 1000 port reads/writes or single bit reads/writes per second, typ
Input high voltage	2.0 V min, 5.5 V absolute max
Input low voltage	0.8 V max, –0.5 V absolute min
Output high voltage (IOH = –2.5 mA)	3.8 V min
Output low voltage (IOL = 2.5 mA)	0.7 V max
Power on and reset state	Input

External trigger

Table 8. External trigger specifications

Parameter	**Conditions**	**Specification**
Trigger source (Note 3)	External digital	TRIG_IN
Trigger mode	Software selectable	Edge Sensitive: user configurable for CMOS compatible rising (default) or falling edge.
Trigger latency		10 µs max
Trigger pulse width		1 µs min
Input high voltage		4.0 V min, 5.5 V absolute max
Input low voltage		1.0 V max, –0.5 V min
Input leakage current		*±1.0µA*

Note 3: TRIG_IN is a Schmitt trigger input protected with a 1.5 k Ohm series resistor.

External clock input/output

Table 9. External clock I/O specifications

Parameter	**Conditions**	**Specification**
Pin name		SYNC
Pin type		Bidirectional
Software selectable direction	Output	Outputs internal A/D pacer clock.
	Input	Receives A/D pacer clock from external source. Rising edge sensitive.
Input clock rate		50 kHz, max
Clock pulse width	Input	1 µs min
	Output	5 µs min
Input leakage current		*±1.0 µA*
Input high voltage		4.0 V min, 5.5 V absolute max
Input low voltage		1.0 V max, -0.5 V absolute min
Output high voltage (Note 4)	IOH = –2.5 mA	3.3 V min
	No load	3.8 V min
Output low voltage (Note 4)	IOL = 2.5 mA	1.1 V max
	No load	0.6 V max

Note 4: SYNC is a Schmitt trigger input and is over-current protected with a 200 Ω series resistor.

Counter

Table 10. Counter specifications

Pin name	CTR
Counter type	Event counter
Number of channels	1
Input type	TTL, rising edge triggered
Resolution	32 bits
Counter/timer read/write rates; software paced	Counter read: system dependent, 33 reads to 1000 reads per second
	Counter clear: system dependent, 33 reads to 1000 writes per second
Schmidt trigger hysteresis	*20 mV to 100 mV*
Input leakage current	*± 1 µA*
Maximum input frequency	1 MHz
High pulse width	*500 ns min*
Low pulse width	*500 ns min*
Input low voltage	1.0 V min, -0.5 V max
Input high voltage	4.0 V min, 5.5 V max

Memory

Table 11. Memory specifications

Data FIFO	32,768 samples, 65,536 bytes		
EEPROM	1,024 bytes		
EEPROM configuration	**Address range**	**Access**	**Description**
	0x000-0x07F	Reserved	128 bytes system data
	0x080-0x1FF	Read/Write	384 bytes calibration data
	0x200-0x3FF	Read/Write	512 bytes user area

Microcontroller

Table 12. Microcontroller specifications

Type	High performance 8-bit RISC microcontroller
Program memory	16,384 words
Data memory	2,048 bytes

Power

Table 13. Power specifications

Parameter	Conditions	Specification
Supply current	USB enumeration	<100 mA
Supply current (Note 5)	Continuous mode	350 mA typ
User +5V output voltage range (Note 6)	Available at the 5V screw terminal	4.0 V min, 5.25 V max
User +5V output current (Note 7)	Available at the 5V screw terminal	50 mA max

Note 5: The total current requirement for the USB-1616FS which includes up to 10mA for the status LEDs.

Note 6: Output voltage range assumes input power supply voltage is within specified limits

Note 7: The total amount of current that can be sourced from the 5V screw terminal for general use. This specification includes any additional contribution due to DIO loading.

USB +5V voltage

Table 14. USB voltage specifications

Parameter	**Specification**
USB +5V (VBUS) input voltage range	4.75 V min to 5.25 V max

External power input

Table 15. External power input specifications

Parameter	**Conditions**	**Specification**
External power input		+6.0 VDC to 12.5 VDC (9 VDC power supply included).
Voltage supervisor limits – PWR LED. (Note 8)	6.0 V > Vext or Vext > 12.5 V	PWR LED = Off (power fault)
	6.0 V < Vext < 12.5 V	PWR LED = On
External power adapter (included)	MCC p/n CB-PWR-9V3A	+9 V ±10%, @ 3 A

Note 8: The USB-1616FS monitors the external +9 V power supply voltage with a voltage supervisory circuit. If this power supply exceeds its specified limit, the PWR LED will turn off indicating a power fault condition.

External power output

Table 16. External power output specifications

Parameter	**Conditions**	**Specification**
External power output – current range	Note 9	4.0 A max
External power output	Voltage drop between power input and daisy chain power output	0.5 V max
Compatible cable(s) for daisy chain	C-MAPWR-x	X = 2, 3 or 6 feet

Note 9: The daisy chain power output option allows multiple MCC USB Series products to be powered from a single external power source in a daisy chain fashion. The voltage drop between the device power supply input and the daisy chain output is 0.5 V max Users must plan for this drop to assure that the last device in the chain will receive at least 6.0 VDC.

USB specifications

Table 17. USB specifications

USB "B" connector	Input
USB device type	USB 2.0 (full-speed) *Use of multiple USB-1616FS devices requires a USB 2.0 hub*.
Device compatibility	USB 1.1, USB 2.0
USB "A" connector	Downstream hub output port
USB hub type	Supports USB 2.0 high-speed, full-speed, and low-speed operating points
	Self-powered, 100mA max downstream VBUS capability
Compatible products	MCC USB Series devices
USB cable type (upstream and downstream)	*A-B cable, UL type AWM 2527 or equivalent (min 24 AWG VBUS/GND, min 28 AWG D+/D–)*
USB cable length	3 meters, max (9.84 feet)

Environmental

Table 18. Environmental specifications

Operating temperature range	0 ° C to 70 ° C
Storage temperature range	–40 ° C to 85 ° C
Humidity	0% to 90% non-condensing

Mechanical

Table 19. Mechanical specifications

Card dimensions (L × W × H)	203.2 × 121.9 × 20.0 mm (8.0 × 4.8 × 0.8 in.)
Enclosure dimensions (L × W × H)	241.3 × 125.7 × 58.9 mm (9.50 × 4.95 × 2.32 in.)

Screw terminals

Table 20. Screw terminal specifications

Connector type	Screw terminal
Wire gauge range	14 AWG to 30 AWG

Table 21. Screw terminal pinout

Board label		**Signal name**	**Board label**		**Signal name**
DIO	0	DIO 0	GND	0	GND 0
	1	DIO 1		1	GND 1
	2	DIO 2		2	GND 2
	3	DIO 3		3	GND 3
	4	DIO 4		4	GND 4
	5	DIO 5		5	GND 5
	6	DIO 6		6	GND 6
	7	DIO 7		7	GND 7
TRIG IN		TRIG IN	CTR		CTR
5V		5V	SYNC		SYNC
CHANNEL IN	0	CH 0	AGND	0	AGND 0
	1	CH 1		1	AGND 1
	2	CH 2		2	AGND 2
	3	CH 3		3	AGND 3
	4	CH 3		4	AGND 4
	5	CH 4		5	AGND 5
	6	CH 5		6	AGND 6
	7	CH 6		7	AGND 7
	8	CH 8		8	AGND 8
	9	CH 9		9	AGND 9
	10	CH 10		10	AGND 10
	11	CH 11		11	AGND 11
	12	CH 12		12	AGND 12
	13	CH 13		13	AGND 13
	14	CH 14		14	AGND 14
	15	CH 15		15	AGND 15

CE Declaration of Conformity

Manufacturer: Measurement Computing Corporation

Address: 10 Commerce Way
Suite 1008
Norton, MA 02766
USA

Measurement Computing Corporation declares under sole responsibility that the product

USB-1616FS

to which this declaration relates is in conformity with the relevant provisions of the following standards or other documents:

EU EMC Directive 89/336/EEC: Electromagnetic Compatibility, EN 61326 (1997) Amendment 1 (1998)

Emissions: Group 1, Class A

- EN 55011 (1990)/CISPR 11: Radiated and Conducted emissions.

Immunity: EN61326, Annex A

- IEC 1000-4-2 (1995): Electrostatic Discharge immunity, Criteria C.
- IEC 1000-4-3 (1995): Radiated Electromagnetic Field immunity Criteria C.
- IEC 1000-4-4 (1995): Electric Fast Transient Burst immunity Criteria A.
- IEC 1000-4-5 (1995): Surge immunity Criteria C.
- IEC 1000-4-6 (1996): Radio Frequency Common Mode immunity Criteria A.
- IEC 1000-4-8 (1994): Magnetic Field immunity Criteria A.
- IEC 1000-4-11 (1994): Voltage Dip and Interrupt immunity Criteria A.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in February, 2005. Test records are outlined in Chomerics Test Report #EMI4133.05.

We hereby declare that the equipment specified conforms to the above Directives and Standards.

Carl Haapaoja, Director of Quality Assurance

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